

*Original*

## **TUBULAR BASEBALL BATS WITH VARIABLE STIFFENED BARRELS**

### **FIELD OF THE INVENTION**

[001] The present invention relates to baseball bats and more particularly to tubular baseball bats, constructed of a variety of materials, and more particularly to baseball bats designed to improve player performance as defined by greater hitting distance, and more particularly to baseball bats whose performance as defined by hitting distance is controlled by performance standards established by regulatory bodies.

### **BACKGROUND OF THE INVENTION AND PRIOR ART**

[002] Baseball and softball bats, hereinafter referred to simply as “baseball bats” or “bats”, are today typically made solely from aluminum alloys, or aluminum alloys in combination with composite materials (hybrid bats), or most recently solely from composite materials (with the exception of solid wooden bats for the Major Leagues). Such bats are tubular (hollow inside) in construction in order to meet the weight requirements of the end user, and have a cylindrical handle portion for gripping, a cylindrical barrel portion for striking, and a tapered mid-section connecting the handle and barrel portions. Such bats have constant stiffness along their barrel portion length.

[003] When aluminum alloys initially replaced wooden bats in most bat categories, the original aluminum bats were formed as a single member, that is, they were made in a unitary manner as a single-walled aluminum tube for the handle, taper, and barrel portions. Such bats are often called single-wall aluminum bats and were known to improve performance relative to wooden bats as defined by increased hit distance. More recently (in the mid 1990’s), improvements in bat design largely concentrated on further improving bat performance. This was accomplished primarily by thinning the barrel or hitting portion of the bat frame and adding inner or internal, and or outer or external, secondary members extending along the entire barrel length; these members are often referred to respectively as inserts or sleeves; while the main member is often referred to

as a body, shell or frame in the prior art. Such bats are often called double-wall bats or multi-walled bats in the case of more than two walls.

**[004]** The prior art of such double walled and multi-walled tubular bats generally refer to improved performance or hit distance resulting from trampoline effect, spring, compliance, rebound, flexibility, etc. resulting from the multi-wall two or more member construction along the entire barrel length allowing the barrel portion of the bat to deflect or flex more upon ball impact which propels the ball faster and further than prior art bats. The scientific principle governing improved bat performance is bending theory. When a ball impacts a bat it has kinetic energy that must be absorbed by the bat in order to stop the ball. The bat stores this energy by flexing. After the ball is stopped, the bat returns the energy it stored by rebounding and sending the ball back towards where it came from. The more the bat barrel or striking portion deforms upon ball impact without failing (denting or breaking), the lower the energy loss in the ball, and the greater the energy return to the ball from the bat as the tubular bat barrel portion impacted returns to its original shape. To allow the bat barrel portion to deform, requires lowering the radial stiffness of the barrel portion. The prior art double walled and multi-walled tubular bats accomplish this by thinning the main member barrel portion and adding thin secondary member insert(s) and/or sleeve(s) which are not joined to the main member, extend full length of the barrel portion, and result in lowered constant stiffness along the barrel portion.

**[005]** US Patent 5,303,917 to Uke discloses a two member bat of thermoplastic and composite materials.

**[006]** US Patent 5,364,095 to Easton discloses a two member bat consisting of an external metal tube and an internal composite sleeve bonded to the inside of the external metal tube and running full length of the barrel portion of the bat.

**[007]** US Patent 6.322.463B1 to Chauvin discloses the method of tuning a unitary member all composite bat.

[0008] US Patent 5,415,398 to Eggiman discloses a two member metallic bat consisting of a frame and internal insert of constant thickness running full length of the barrel portion of the bat in a double-wall construction. Further, US patents 6,251,034B1 and 6,482,114B1 disclose variations to 5,415,398. Further, US Patent 6,251,034B1 discloses a polymer composite second tubular member running full length of the barrel portion of the bat with the members joined at the ends only of the barrel portion with the balance of the composite member freely movable relative to the primary member. US patents 6,440,017B1 and 6,612,945 B1 to Anderson also disclose two member bats with an outer sleeve and inner shell of constant thickness running full length of the barrel portion..

[0009] US patent 6,063,828 to Pitzenberger discloses a two member bat consisting on an internal body and an external shell of constant thickness running full length of the barrel portion in a double-wall construction. US patent 6,461,760B1 to Higginbotham discloses the bat of 6,053,828 with a composite shell formed to an outer shell running full length of the barrel portion of the bat.

[0010] Similarly, US Patent 6,425,836B1 to Mizuno discloses a two member bat with a lubricated coating between layers or a weak boundary layer formed on the surfaces of the inner member.

[0011] US Patent Pub. 2001/0094882 A1 by Clauzin discloses a two member bat consisting of an outer shell and an insert laminate partially bonded to the shell.

[0012] In all prior art multi-walled tubular bats, the bat frame primary and secondary members extend along the entire barrel length and are of constant thickness. Also, the bat members are not joined, except at their ends, in order to reduce radial stiffness of the barrel portion to improve bat performance. Also, in all cases, the radial stiffness of the barrel portion is uniform or constant full length of the barrel portion of the bats.

[0013] While the prior art single member, and more particularly, double-walled and multi-walled tubular bats have demonstrated improved performance as claimed, various regulatory bodies have raised safety concerns regarding improved performance bats and

thus, some have established maximum performance standards for various categories of baseball bats under their jurisdiction. As a result, manufacturers of baseball bats are required to pass various controlled laboratory tests, such as, bbf (batted ball performance), bbs (batted ball speed), etc. Further, for a given bat category (eg. slowpitch softball), there may be two or more regulatory bodies each of which may establish a different standard. Further, any of the regulatory bodies may change their standard from time to time. Such new or changed or varying regulations are extremely problematic, costly, and disruptive for both manufacturers and players.

**[0014]** The one solution to the problem of lowering performance of the prior art bats in order to meet new or changed performance standards is to increase thickness full length of one or more of the barrel members, and/or the single wall bat frame, which increases radial stiffness thus reducing performance. The increased wall thickness solution of the prior art tubular bats applied along the entire barrel length of either the main member frame and/or secondary barrel members can increase weight such that the finished bat weight standard or objective is exceeded and thus, the bat in question is obsolete. This results in costly inventory write-offs for the manufacturer while individual players must replace an otherwise good bat with a new bat which meets the current standards. Further, the manufacturer incurs significant redesign and retooling costs and marketing timing issues (ie. for at least a period of time, have no bat which meets the new standard).

**[0015]** Therefore, what is needed is a simple, low cost invention to decrease bat performance of tubular bats in a controlled manner, in order to meet lowered or changed bat performance standard requirements without significantly increasing bat weight. Further, what is needed is that such an invention can be employed for both new bats being manufactured and used bats returned from players (to be returned to players with lowered performance to meet the new or changed standard involved). Further, what is needed is the required performance decrease at least partially be offset by improving another bat characteristic such as "sweetspot" (barrel portion length of maximum bat performance) size. Also, what is needed is newly designed tubular bats with a predetermined bat performance with larger sweetspot areas than bats of the prior art.

## **SUMMARY OF THE INVENTION**

[0016] Therefore, in view of the foregoing, what is needed is tubular baseball bats with variable stiffness along their barrel portions. A main object of the present invention is to provide tubular baseball, and particularly existing bats, with changed (usually decreased) bat performance, without significantly increased weight, in order to meet new or changed performance standards. To achieve this, the bats of the present invention are stiffened in the barrel area of peak bat performance commonly referred to as the sweetspot. Typically, this is an area approximately 2" to 4" in width as compared to barrel portion lengths of 4" to 16". This is achieved by inserting or adding to the bat a circumferential stiffener in the region of the sweetspot.

[0017] The preferred short light weight polymer composite circumferential stiffener employed adds only minimal weight to a given bat thus allowing the stiffened bat to be continued to be used within the required weight requirements of baseball. The stiffener of the present invention can be added to used bats returned from players for modification to meet a changed regulation and also can be added to bats manufactured before a regulation change occurs, allowing such previously manufactured bats to meet a changed standard. Though somewhat heavier, a short metallic stiffener could also be employed. An alternative solution of the present invention to vary stiffness, and thus bat performance, along the barrel portion is to vary thickness along the barrel portion.

[0018] A second object of the present invention is to provide tubular bats with bat performance decreased to meet a given changed regulation in a precisely controlled manner; that is, if the standard requires a standard of  $x$  maximum and a given bat design has a performance greater than  $x$ , then following the precisely located stiffening, the bat performance will meet the  $x$  requirement and not be significantly less than  $x$ . In the present invention, this is accomplished by engineering calculations considering selection of the composite fiber type, the fiber size, the angles of the fibers, and the thickness of the polymer composite stiffener to be employed to precisely lower the bat performance. Proper engineering design of these variables of a polymer composite results in a polymer composite stiffener which when added to a tubular bat results in that bat precisely meeting the desired new bat performance.

[0019] A third object of the present invention is to provide existing tubular bats with a specific predetermined bat maximum bat performance with a larger sweetspot than tubular bats of the prior art. In the present invention this is accomplished by precisely stiffening only the peak performance area (generally the sweetspot area) of the existing bat to the performance level of the barrel portion areas immediately adjacent on both sides of the sweetspot of the unstiffened bat. The resultant effect is to approximately double the sweetspot size (that is, the area of the barrel portion which provides maximum bat performance).

[0020] A fourth object of the present invention is to provide newly designed tubular all polymer composite baseball bats with a predetermined bat performance with larger sweetspot areas than bats of the prior art. In the present invention this is accomplished by graduating the radial stiffness of the barrel portion along the entire barrel length. Specifically, the peak performance area (generally the sweetspot area) is designed to have the highest radial stiffness while the area of the barrel portion nearest the taper and barrel ends have the lowest radial stiffness and with the barrel portion between the sweetspot and barrel ends being graduated. The resultant effect is a sweetspot area that runs substantially full length of the barrel portion. In the present invention this is accomplished by engineered selection of the composite fiber type(s), fiber sizes(s), fiber angles(s), and the total composite multi-layered laminate or structure having graduated radial stiffness along the barrel portion length.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0021] The invention will now be described with reference to the accompanying drawings, in which:

[0022] Fig. 1 shows a longitudinal cross-section of a typical prior art single wall tubular bat with a singular frame, or member, construction.

[0023] Fig. 1A shows a cross-sectional area take at any location through the barrel portion of the Fig. 1 prior art tubular bat.

[0024] Fig. 2 shows a longitudinal cross-section of a typical prior art double-wall tubular bat with two separate members, a frame or main member with an internal insert as

a secondary member in the barrel area. Both the frame and insert run the full length of the barrel portion and are not joined full length.

[0025] Fig. 2A shows a cross-sectional area taken at any location through the barrel portion of the Fig. 1 prior art tubular bat.

[0026] Fig. 3 shows a longitudinal cross-section of a typical prior art double-wall tubular bat with two separate members, a frame or main member with an external sleeve secondary member in the barrel portion. Both the frame and sleeve run the full length of the barrel portion and are not joined full length.

[0027] Fig. 3A shows a cross-sectional area taken at any location through the barrel portion of the Fig. 2 prior art tubular bat.

[0028] Fig. 4 shows a longitudinal cross-section of one embodiment of the present invention showing a single wall tubular bat in accordance with the present invention showing an internal stiffener generally confined to the sweetspot area of the barrel portion and joined to the barrel portion.

[0029] Fig. 4A shows a cross-sectional area of a barrel location not within the sweetspot area.

[0030] Fig. 4B shows a cross-sectional area within the sweetspot area showing the internal stiffener of the present invention.

[0031] Fig. 5 shows a longitudinal cross-section of a second embodiment of the present invention showing a single wall tubular bat in accordance with the present invention with an external stiffener generally confined to the sweetspot area of the barrel portion and joined to the barrel portion.

[0032] Fig. 5A shows a cross-sectional area at a barrel location not within the sweetspot area.

[0033] Fig. 5B shows a cross-sectional area within the sweetspot area showing an external stiffener of the present invention.

[0034] Fig. 6 shows a longitudinal cross-section of a third embodiment of the present invention showing a single wall polymer composite tubular bat in accordance with the

present invention showing a localized area of the fiber type and/or angle change resulting in increased radial stiffness generally confined to the sweetspot area of the barrel portion.

[0035] Fig. 6A shows a cross-sectional area at a barrel location not within the sweetspot area.

[0036] Fig. 6B shows a cross-sectional area within the sweetspot area showing a stiffened area of changed fiber angles and/or type.

[0037] Fig. 7 shows a longitudinal cross-section of a fourth embodiment of the present invention showing a double-wall tubular bat with two separate members, a frame or main member with an internal insert as a secondary member full length in the barrel portion, and in accordance with the present invention, showing an internal stiffener generally confined to the sweetspot area of the barrel portion and joined to the barrel portion.

[0038] Fig. 7A shows a cross-sectional area at a barrel location not within the sweetspot area.

[0039] Fig. 7B shows a cross-sectional area within the sweetspot area showing the internal stiffener.

[0040] Fig. 8 shows a longitudinal cross-section of a fifth embodiment of the present invention showing a double-wall tubular bat with two separate members, a frame or main member with an external sleeve as a secondary member full length in the barrel portion, and in accordance with the present invention showing an external stiffener generally confined to the sweetspot area of the barrel portion and joined to the barrel portion.

[0041] Fig. 8A shows a cross-sectional area at a barrel location not within the sweetspot area.

[0042] Fig. 8B shows a cross-sectional area within the sweetspot area showing the external stiffener.

[0043] Fig. 9 shows in graphical form the typical relationship between tubular bat performance and barrel location and sweetspot size.



[0044] Fig. 10 shows in graphical form a typical relationship between tubular bat performance of a bat of the present invention with an internal stiffener, and barrel location and sweetspot size.

#### **DETAILED DESCRIPTION OF THE INVENTION**

[0045] The present invention is directed to providing tubular baseball bats with bat performance decreased in a controlled manner, to meet changing regulatory standards, without significantly increasing bat weight (Fig. 4, 5, 6, 7 and 8). Further, such decreased bat performance can be achieved in a simple manner at reasonably low costs and applied to both bats being manufactured or returned from end users. Further, such bats of the present invention can have a larger sweetspot size.

[0046] The prior art bats are shown in Figs. 1, 2, and 3. Fig. 1 shows a single wall tubular bat with main member 16. Fig 2 shows a double wall tubular bat with an insert 13, formed separately from the main member 16, which is fitted into the entire barrel length 1 of the main member 16. Fig. 3 shows a double wall tubular bat with a sleeve 14, formed separately from the main member 16, which is fitted over the entire barrel length 1 of the main member 16.

[0047] Though not indicated in Figs. 1 through 8, bats of the present invention, as do bats of the prior art, include a traditional knob (not shown in the drawings) at the handle portion end 5 and a traditional end cap (not shown in the drawings) at the barrel portion end 4, both of which can be made from a variety of materials.

[0048] Most adult tubular baseball bats of the prior art have maximum outside barrel portion diameter 2 either 2.625 or 2.75 inches. Depending on the taper portion geometry of the mid-section 8, and the total length of the bat, the barrel length 1 as defined by length of constant maximum diameter 2, ranges from 4 to 12 inches. Barrel wall thickness 6 ranges from .100 inches to .140 inches for aluminum bats and up to .220 inches for all composite bats.

**[0049]** Most youth baseball bats and softball bats of the prior art have maximum outside barrel portion diameter 2 of 2.25 inches. Depending on the taper portion geometry of the mid-section 8, the barrel length 1 ranges from 4 to 16 inches. Barrel wall thickness 6 ranges from .060 to .090 inches for aluminum bats and up to .220 inches for all composite bats.

**[0050]** The bats of the present invention, shown in Figs. 4, 5, 6, 7 and 8 have similar dimensions to the foregoing prior art bats shown in Figs. 1, 2 and 3.

**[0051]** A first embodiment of the present invention Fig. 4 is a single wall tubular baseball bat consisting of a cylindrical handle portion 7 for gripping, a cylindrical tubular barrel portion 9 for striking or hitting, and a tapered mid-section 8 connecting the handle 7 and barrel 9 portions, with a thin polymer composite stiffener 18 located internally within the barrel portion 9 and extending longitudinally in the sweetspot area 19 of the barrel length 1.

**[0052]** A polymer composite is a non-homogenous material consisting of continuous fibers embedded in, and wetted by, a polymeric resin matrix whereby the properties of the material are superior to those of its constituent fibers and resin taken separately. Such polymer composites are anisotropic materials since they exhibit different responses to stresses applied in different directions depending on how the fibers are aligned or angled within the matrix.

**[0053]** Other materials commonly used in bat constructions such as aluminum, wood and plastics are not anisotropic and are thus limited in controlling bat performance; for example, radial stiffness is equal to longitudinal stiffness and cannot be graduated along the barrel length 1. However, with composite materials, which are preferred, properties of bats made in accordance with the present invention, such as radial stiffness which determines bat performance can be controlled (i.e. designed to a given requirement) by altering such parameters as the fiber alignments along the bat length 1, and/or the type of fibers chosen, their denier or layout density and/or the thickness of the polymer composite structure.

[0054] Generally, the fiber materials used are selected from a group consisting of fiberglass, graphite or carbon, aramid, boron, nylon, or hybrids of any of the foregoing, all of which are commercially available. The resins used to impregnate, wet out, and encapsulate or imbed the fiber materials are generally selected from a group consisting of epoxy, polyester, vinyl ester, urethane, or a thermoplastic such as nylon, or mixtures thereof.

[0055] The first embodiment Fig. 4 of the present invention consists of a thin polymer composite stiffener 18 located internally within the barrel portion 9 generally in the sweetspot area 19 located in proximity to the middle area of the barrel length 1 of a single wall tubular bat. The resultant stiffened bat results in a predetermined calculated lower performance, with a bigger (longer) sweetspot 19, as subsequently explained.

[0056] The sweetspot area 19 of a baseball bat is generally referred to as that area along the barrel length 1 in which bat performance is greatest; that is, a ball struck within the sweetspot area 19 will travel further than a ball struck on either side of the sweetspot area. Typically, the sweetspot area 19 is located around the middle of the barrel length 1 and is in the order of 2" to 4" in length as compared to barrel lengths 1 ranging from approximately 4" to 16" or more.

[0057] In actual practice, the performance of a baseball bat of the prior art follows a statistical normal distribution along the barrel length 1, usually centered near the middle of the barrel length 1 in the sweetspot area 9. Figure 9 shows a typical bat performance distribution example with a 12" barrel length 1.

[0058] In Figure 9, the maximum bbs (one measure of bat performance standard) is 100 while most players would describe the sweetspot as being approximately 2" long (that is, the portion of the barrel length equal to or greater than 98 bbs). The bat of this particular sample meets a bat performance factor standard of 100 bbs maximum if so regulated.

[0059] If the applicable regulatory body for the bat in the Figure 9 example changed the bat performance standard from 100 bbs maximum to say 96 bbs maximum, the bat of

the present invention with a specifically designed 4" polymer composite stiffener 18 located in the center of the barrel length 1. Figure 10 shows the bbs versus barrel length for this example.

[0060] In Figure 10, in an example of the present invention, the polymer composite stiffener 18 is approximately twice as stiff in the center 2" of the sweetspot area 19 as in the 1" area immediately adjacent to the center area on each side of the center area. The polymer composite stiffener 18 fiber type, fiber angles and thicknesses are designed such as to reduce the bbs from 100 to 96 in the center area 2" of the barrel length 1 and from 98 to 96 bbs in the 1" areas immediately adjacent to the center area. As a result of the present invention, the resultant typical example bat meets the lowered regulatory standard of 96 bbs with a sweetspot area 19 which has been increased by 100% (from 2" wide to 4" wide).

[0061] The first embodiment (ie. internal stiffener 18) of the present invention is particularly suited to retrofitting used bats returned by players and making legally playable under a revised standard.

[0062] The thin polymer composite stiffener 18 of the present invention is typically in the order of .005" to .040" thick with length 2" to 6" which is typically less than 50% of the barrel length and is preferably bonded, fully or partially, to the main member 16, or to the secondary member insert 13 of Fig. 7 or to the secondary member sleeve 14 of Fig. 8, or combinations thereof. Though not shown, an alternative solution (since stiffness is proportional to thickness) to the stiffener 18 is to vary the barrel thickness 6 along the barrel length 1, either full length or any portion of the barrel length 1 in order to vary bat performance.

[0063] A second embodiment of the present invention Fig. 5 is a single wall tubular baseball bat which in accordance with the present invention has a thin polymer composite stiffener 18 located externally to the barrel portion 9 generally in the sweetspot area 19 located in proximity to the middle area of the barrel length 1. The resultant stiffened bat results in a calculated lower performance, with a bigger (longer) sweetspot 19, as previously explained.

**[0064]** A third embodiment of the present invention Fig. 6 is a single wall tubular polymer composite baseball bat which in accordance with the present invention has a localized area of fiber type and/or angle change 20 resulting in increased radial stiffness generally in the sweetspot area 19 located in proximity to the middle area of the barrel length 1. Though not shown, this embodiment applies equally well to double-wall and multi-wall (more than two walls) tubular all polymer composite baseball bats and is limited to newly designed polymer composite single wall, double-wall, and multi-walled new bats as opposed to field returned bats. Though not shown, the fiber types, and/or fiber angles, and/or fiber sizes, and/or composite thickness can be designed such as to graduate the radial stiffness of the barrel portion 1 along its entire length. That is, the radial stiffness could be highest in the peak performance area (generally the sweetspot area 19) and gradually changing in uniform increments towards the barrel ends where the radial stiffness would be lowest. The resultant effect is a sweetspot area 19 that extends substantially full length of the barrel portion 1.

**[0065]** A fourth embodiment of the present invention Fig. 7 is a double-wall tubular bat showing two separate members, a frame or main member 16 with an internal insert 13 as a secondary member full length in the barrel length 1, and in accordance with the present invention has a stiffener 18 located internally within the insert 13 generally confined to the sweetspot area 19, along the barrel length 1. Though not shown, the stiffener 18 could be located externally to the main member 16 or between the main member 16 and the internal insert 13. Also, though not shown, in multi-walled bats the stiffener 18 could be located internally, or externally, or between the members, or combinations thereof.

**[0066]** A fifth embodiment of the present invention Fig. 8 is a double-wall tubular bat showing two separate members, a frame or main member 16 with an external sleeve 14 as a secondary member full length in the barrel length 1, and in accordance with the present invention has a stiffener 18, located externally to the sleeve 14, generally confined to the sweetspot area 19, along the barrel length 1. Though not shown, the stiffener 18 could be located internally to the main member 16 and the external sleeve 14. Also, though not

shown, in multi-walled bats, the stiffener 18 could be located internally, or externally, or between the members, or combinations thereof.

[0067] The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.